SCOUR AROUND BRIDGE PIERS AND ABUTMENTS

by

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INTRODUCTION

Man's never-ending search for better materials and construction methods and for techniques of analysis and design has overcome most of the early difficulties of bridge building. Scour of the stream bed, however, has remained a major cause of bridge failures ever since man learned to place piers and abutments in the stream in order to cross wide rivers. The bridge builder's concern with scour in the days of the masonry arch is evidenced by the treatises of that time. The massive piers and short spans typical of old arch bridges resulted in extreme contractions of the flow section and, consequently, severe scour. Moreover, the timber-crib foundations placed at or near the original stream bed were particularly vulnerable to undermining. Modern steel and concrete bridges can be built with long spans and relatively small piers. Pile and caisson foundations can be sunk far beneath the stream bed. Yet every year additions are made to the list of bridges that have failed because of scour of the stream bed around the piers and abutments. In fact, the considerable bridge losses in the State of Iowa in the year 1947 were in large measure responsible for the determination of the Iowa State Highway Commission to sponsor an intensive study of the problem with the goal of evolving means for predicting probable scour depths.

Considering the overall complexity of field conditions, it is not surprising that no generally accepted principles (not even rules of thumb) for the prediction of scour around bridge piers and abutments have evolved from field experience alone. The flow of individual streams exhibits a manifold variation, and great disparity exists among different rivers. The alignment, cross section, discharge, and slope of a stream must all be correlated with the scour phenomenon, and this in turn must be correlated with the characteristics of the bed material ranging from clays and fine silts to gravels and boulders. Finally, the effect of the shape of the obstruction itself—the pier or abutment—must be assessed. Since several of these factors are likely to vary with time to some degree, and since the scour phenomenon as well is inherently unsteady, sorting out the influence of each of the various factors is virtually impossible from field evidence alone.

An analytical approach is equally difficult. If an obstruction, such as a pier, is placed in a stream, the flow pattern in the vicinity of that obstruction will be modified. Because the capacity for the transport of sediment is a function of the flow, the transport-capacity pattern will also be modified. In any area where, as a result of the modified pattern, the capacity for transport out of the area is greater than the rate at which material is supplied to the area, scour will occur. Conversely, where the transport capacity is less than the rate of supply, deposition will occur. The resultant changes in the stream bed will further modify the flow pattern—and the capacity pattern—until equilibrium between capacity and supply is again achieved at every point on the stream bed. An analytic solution would have to combine a prediction of the flow pattern and a description of the local transport capacity of the flow. Although an approximation of the flow pattern might be attempted, a comparable solution for the capacity is not yet possible.

The experimental approach has been tried in the past with limited success, usually because the goal was restricted to a particular installation or to some special phase of the general problem. The earliest report on a laboratory study which has come to the attention of the writers is that of Engels at Dresden, Germany, in 1894. In the paper describing that study reference is made to an earlier one in France in 1873 by Durand-Claye. Neither these early experiments nor subsequent studies by various investigators in various countries have been sufficiently general to obtain the desired result—a means of predicting scour in the field.

The experimental approach was chosen as the investigative method for this study, but with due recognition of the importance of field measurements and with the realization that the results must be interpreted so as to be compatible with the present-day theories of fluid mechanics and sediment transportation. This approach was chosen because, on the one hand, the factors affecting the scour phenomenon can be controlled in the laboratory to an extent that is not possible in the field, and, on the other hand, the model technique can be used to circumvent the present inadequate understanding of the phenomenon of the movement of sediment by flowing water.